

A Theory-driven Interpretation and Elaboration of Verification and Validation

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Abstract

This paper presents a formal theory of verification and validation (V&V) within systems engineering, grounded in the axiom that V&V are fundamentally knowledge-building activities. Using dynamic epistemic modal logic, we develop precise definitions of verification and validation, articulating their roles in confirming and contextualizing knowledge about systems. The theory formalizes the interplay between epistemic states, evidence, and reasoning processes, allowing for the derivation of theorems that clarify the conceptual underpinnings of V&V. By providing a formal foundation, this work addresses ambiguities in traditional V&V practices, offering a structured framework to enhance precision and consistency in systems engineering methodologies. The insights gained have implications for both academic research and practical applications, fostering a deeper understanding of V&V as critical components of engineering knowledge generation.

Keywords: verification; validation; theory of systems engineering; foundations of systems engineering

1. Introduction

In this paper, we take a foundational look at verification and validation (V&V) and try to establish a meaningful theoretical framework for them. What is the meaning of verification? What is the meaning of validation? How do they relate to requirements and needs? Are verification and validation activities mutually exclusive, do they overlap, is one a subset of the other? Certainly, past work has addressed some of these questions. For example, verification is often presented as answering the question of *are you building the system right* and validation as *are you building the right system* [1]. While intuitive, some authors have considered them insufficient and have explored them in more detail, concluding that one must differentiate between kinds of verification (e.g., requirements verification versus system verification) and between kinds of validation (e.g., requirements validation vs system validation) [2, 3]. Yet, these taxonomies lack an underlying and internally consistent theoretical framework that offers constructs to enable formal reasoning. As a result, there is no formal manner to assess the adequacy of the concepts, their correctness, internal consistency, and soundness, leaving us only with our intuition of the problem. Among others, this can lead to confusion, disagreement, and misuse of terms because they do not enable testing the truthfulness of its statements, as has been shown for example in problem formulation when articulating concepts associated with needs and requirements [4, 5]. Recent work has attempted to characterize validation in Systems Engineering using propositional logic, but these efforts remain preliminary and do not yet offer a comprehensive theoretical foundation [6].

Past work that has attempted to take a more formal approach towards conceptualizing V&V has focused on formally modeling verification strategies [7-10], using math to design verification strategies [11-24], or developing insights about the relationship between verification models and requirements [25]. This work used some axiomatic framework to interpret what verification and/or validation were, but the consistency and soundness of the assumptions were not formally tested. This paper helps in bridging that gap.

Material Accountability Theory Verification And Applications

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Material Accountability Theory Verification And Applications:

Material Accountability Rudolf Avenhaus,1977 **Energy Research Abstracts** ,1978 **Safeguards Systems**

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